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GEOLOGICAL MAP

OF THE

UNITED STATES.

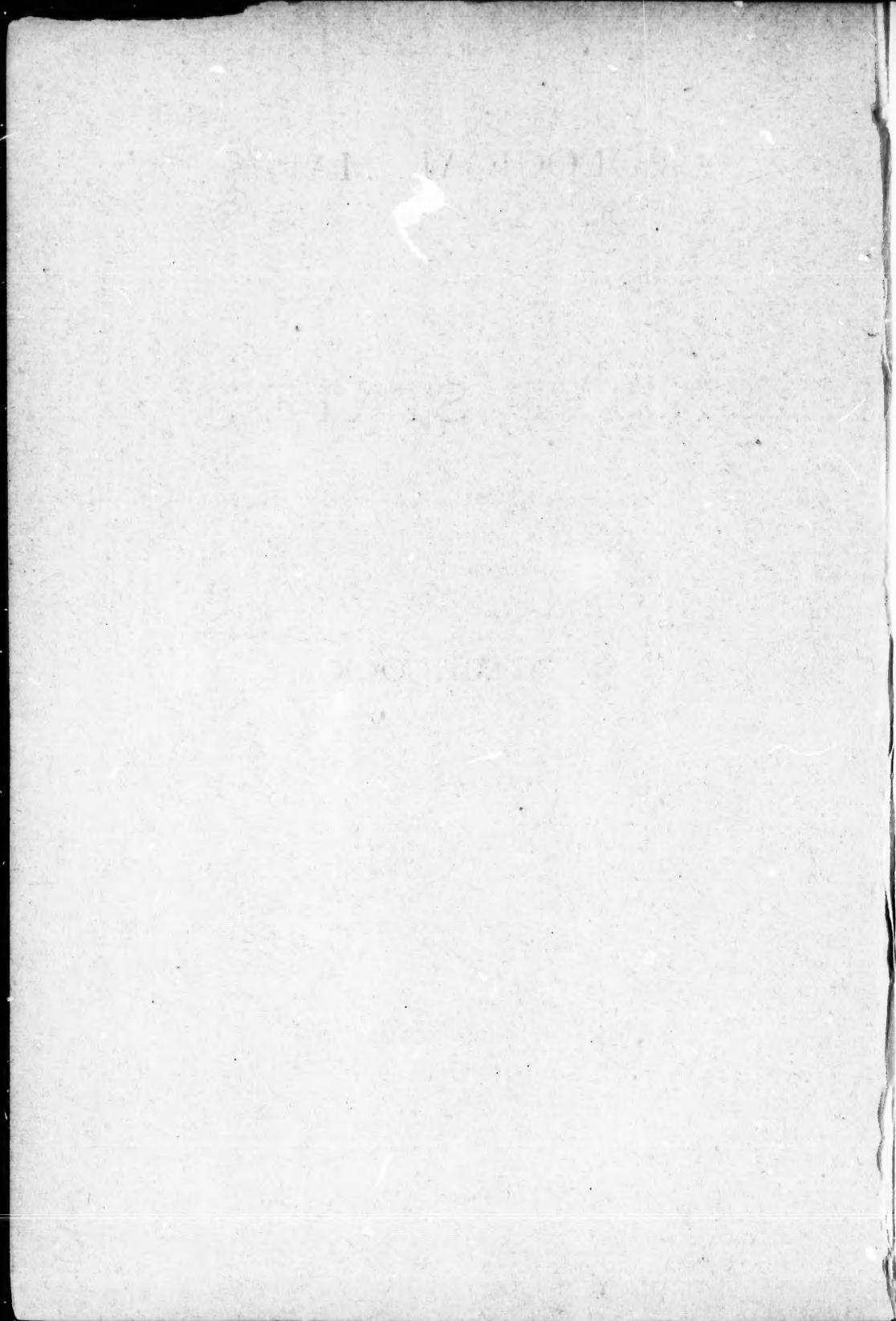
COMPILED BY

C. H. HITCHCOCK.

NEW YORK:

PUBLISHED BY JULIUS BIEN, 18 PARK PLACE.

1881.



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LIBRARY
GEOLOGICAL SURVEY
1881

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GEORGIA STATE UNIVERSITY
AT GAINESVILLE

GEOLOGICAL MAP OF THE UNITED STATES,

COMPILED BY

C. H. HITCHCOCK.

Since printing the pamphlet, we have been enabled to color approximately the outlines of the Eocene and Miocene in Florida, as furnished by Prof. E. A. Smith, the details to be published in the AMERICAN JOURNAL OF SCIENCE.

G. M. DAWSON,	J. P. LESLEY,	C. A. WHITE,
C. E. DUTTON,	S. S. LYON,	R. P. WHITEFIELD,
S. F. EMMONS,	W. J. McGEE,	J. D. WHITNEY,
W. M. FONTAINE,	J. S. NEWBERRY,	A. WINCHELL,
G. K. GILBERT,	RICHARD OWEN,	N. H. WINCHELL,
ARNOLD HAGUE,	J. W. POWELL,	A. H. WORTHEN.

All the published reports by the United States and State Governments, as well as the minor publications enumerated in Frederick Prime, junior's catalogue, have been made use of as far as practicable.

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GEOLOCAL SURVEY
OF CAMBIA

GEOLOGICAL MAP OF THE UNITED STATES,

COMPILED BY

C. H. HITCHCOCK.

The object of this pamphlet is not to draw geological conclusions from the materials now brought together, but to state briefly upon what authority every part of the map has been based.

In its compilation the following geologists have been consulted, and I am indebted to them for valuable aid rendered:

ROBERT BELL,	JAMES HALL,	R. PUMPELBY,
WM. P. BLAKE,	F. V. HAYDEN,	W. B. ROGERS,
S. B. BUCKLEY,	E. W. HILGARD,	J. M. SAFFORD,
THOMAS CONDON,	F. S. HOLMES,	A. R. C. SELWYN,
G. H. COOK,	E. E. HOWELL,	N. S. SHALER,
E. D. COPE,	T. STERRY HUNT,	E. A. SMITH,
E. T. COX,	W. C. KERR,	J. J. STEVENSON,
JOHN COLLETT,	CLARENCE KING,	G. C. SWALLOW,
J. D. DANA,	H. C. LEWIS,	W. UPHAM,
G. M. DAWSON,	J. P. LESLEY,	C. A. WHITE,
C. E. DUTTON,	S. S. LYON,	R. P. WHITEFIELD,
S. F. EMMONS,	W. J. MCGEE,	J. D. WHITNEY,
W. M. FONTAINE,	J. S. NEWBERRY,	A. WINCHELL,
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All the published reports by the United States and State Governments, as well as the minor publications enumerated in Frederick Prime, junior's catalogue, have been made use of as far as practicable.

The effort to prepare this map took shape nearly fifteen years since. At first we proposed to issue separate maps of the different States and territories, using such scales of dimension as best suited the perfection of the facts and the size of the districts. These maps were to have been published in atlas form, accompanied by descriptive text, prepared, when possible, by the authors of the respective maps. In answer to our solicitations, many maps and manuscripts made their appearance, some of which have since been published; but our desire for greater accuracy of information and its acquisition by tedious field-work in New England prevented the execution of the original scheme. Meanwhile we have presented to the public an epitome of our materials: first, in connection with the report of the Superintendent of the Ninth Census; second, in the report of the Commissioner of Mining Statistics; thirdly, in Walker's Statistical Atlas, 1874; and fourthly, upon a large scale for the exhibit of the Smithsonian Institution at the International Exhibition at Philadelphia in 1876. Prof. W. P. Blake assisted us in the preparation of these four editions.

We have now to announce the completion of our labors in the publication of this geological map of the United States, by Julius Bien, of New York. The base used is the Centennial map of the United States (edition of 1879), drawn upon the scale of twenty miles to the inch. This gives, when mounted, a sheet thirteen feet long and eight feet wide. It is made for a wall map, and hence cannot exhibit minute details of topography. The principal lakes, rivers, railroads, cities, towns, railroad stations, mountain ranges, and all the counties are represented. Prof. Blake has prepared for us the coloration of California and portions of Nevada and Arizona.

We have not yet a universally acceptable scheme of

nomenclature for the formations, nor have geologists agreed as to the colors which will most appropriately designate them. Our endeavor is to employ those names of groups which are in common use, with the frequent mention of synonyms. The minute subdivisions of the New York and other systems of classifications cannot be carried out all over the country, and therefore many difficulties of terminology are avoided, since only the more general terms need to be stated. The following table expresses the classification adopted in the legend:

MESOZOIC.	CENOZOIC.	Quaternary.
		Newer.
		Middle.
		Older.
PALEOZOIC.		Laramie or Lignitic group.
		Cretaceous.
		Jurassic and Triassic.
		Permo-Carboniferous.
EOZOIC OR ARCHEAN.		Upper Coal Measures, usually above the Pittsburg Coal.
		Lower Coal Measures, including the Millstone Grit.
		Lower or Sub-Carboniferous.
		Devonian [Catskill to Oriskany].
		Upper Silurian [Lower Helderberg to Oneida].
		Lower or Cambro-Silurian [Lorraine or Hudson River to Calciferous Sandrock].
		Cambrian.
		Huronian.
		Gneiss of Atlantic slope, including Montalban, and metamorphic Paleozoic.
		Labrador or Norian.
		Laurentian.

Eruptive. {
 Granite.
 Volcanic.

Southern margin of the Eastern American ice sheet; also, terminal moraines east and west of Ohio.

The Quaternary includes recent river deposits, oceanic additions to the Tertiary continent, desert sands, and lacustrine deposits of the Far West. An attempt is also made to show the course of the supposed glacial terminal moraines, from Cape Cod to the Saskatchewan region. The terms Pliocene, Miocene, and Eocene are essentially synonymous with our designations of Upper, Middle, and Lower Tertiary—the latter allowing more latitude of reference than the former. The Laramie group is represented by itself, partly because of its importance, and partly because of some disagreement as to its exact place in the series. Perhaps a twofold subdivision of the rest of the Cretaceous might have been practicable. Prominence is given to the several members of the Carboniferous, because of the economic importance of the Coal Measures. Recent observations suggest the presence of several areas of the Permo-Carboniferous, both in the east and the west. The evidence for it in Pennsylvania and West Virginia is less satisfactory than in Texas, Indian Territory, Kansas, and Colorado. The lower division of the Coal Measures extends to include the conglomerate at their base, and hence to include a larger area than is actually underlaid by workable coal. The Catskill group is taken for the upper and the Oriskany for the lower limit of the Devonian, though there is a diversity of opinion as to the propriety of this restriction, especially as to the lower member, which is very commonly placed with the Silurian. The commencement of the Lower or Cambro-Silurian

with the Calciferous Sandrock is generally acceded to at the present day. Some prefer to write Siluro-Cambrian instead of Cambro-Silurian, as originally proposed by Sedgwick, and quite extensively used by English geologists. The word Cambrian suggests a world of contention. Our representation covers the areas termed by authors the Potsdam, Acadian or St. Johns, Keweenian or Keweenawan, Lake Superior, St. Croix, much of the Taconic, etc., besides various mica schist groups in New England, and the itacolumites of the Southern States. There is not entire agreement in the reference of many eastern terranes to the Huronian. Certain areas in Michigan and Wisconsin might be correlated with the gneisses of the Atlantic slope, commonly called Montalban; but in the present state of opinion it has not seemed best to separate them from the Laurentian. I understand the Montalban to represent gneissic areas in the upper part of what might very naturally be called Laurentian. They underlie the Huronian and seem to be unconformable with the Laurentian beneath. Some authors regard the Montalban as metamorphic Silurian and Devonian, others as post-Huronian but pre-Silurian. The term Upper Laurentian was originally applied to the Labrador or Norian series. This group is represented in Canada and New York by a special color, in accordance with the definitions of Logan and Sterry Hunt. In the West, the term Laurentian includes everything below the Huronian. Granite, essentially eruptive, is distinguished by a separate color so far as possible. Much more of it remains to be separated from the Laurentian. The modern volcanic ejections of the West are distinguished as a class without subdivision. The trap division is not represented at all.

It is possible to give much fuller details of the Paleozoic formations in the Appalachian region, but not in

the West; and, therefore, for the sake of uniformity, the smaller series have been merged in the larger. In the following text, also, certain special variations in the significance of the colors will be mentioned.

After reducing the maps of adjacent States, by different authors, to our scale, it often appears that the colors will not fit each other. This may be due to differences of opinion as to the proper limits of the several groups or to incorrect maps. To harmonize such differences is a matter of great difficulty and often impossible, and has led us to adopt the following principle for our guidance. We assume that each geologist understands his own territory better than any one else, and therefore follow his division lines to his boundaries, where a forced connection is made with his neighbor's delineations. If great incongruities are occasioned by this course, a statement of the case will be made in the following pages.

Objection is sometimes made to the attempt to prepare a geological map of the whole United States, that over large areas the character of the underlying formations is not known, and that consequently the student is perplexed by not knowing what is well determined and what is hypothetical. Some suggest that where great uncertainty exists, no attempt should be made to represent even what is probable. I have in some cases left blank spaces in the entire absence of any attempt at exploration. In other cases I have used a broken instead of a solid color, thus enabling all to perceive at a glance where the structure has not been worked out satisfactorily. In some special cases the difficulties of coloration are particularly described.

With these general remarks we proceed now to state specifically what authorities have been used for the representation of the geology of all parts of the map. Yet we

have not space enough to acknowledge many of the smaller items of information kindly furnished by our correspondents.

DOMINION OF CANADA.

Every possible facility for the acquisition of the latest information about the distribution of the formations in that part of Canada embraced in our map has been cheerfully furnished by A. R. C. Selwyn, the accomplished Director of the Geological Survey. The sheets have been submitted to him and his assistants; particularly Prof. R. Bell and G. M. Dawson, and their suggestions of improvement have been followed. In fact, Prof. Bell colored, with his own hand, the region north of the paleozoic basin, from Quebec across to the Rocky Mountains. From Lake Winnipeg to the Pacific Ocean we follow the guidance of G. M. Dawson.

Logan's map of 1865 correctly represents the fossiliferous groups from Quebec to Lake Superior. For the eastern townships region, the views of Sterry Hunt and Selwyn are adopted in placing the Lauzon and Sillery beneath instead of above the Levis, the latter containing many primordial types of life. The Canadian extension of the Vermont Green Mountains is referred to the Montalban because it underlies the Huronian. East of Sherbrooke P. Q., the calcareous rocks were referred to the Upper Silurian by Logan. As they seem to merge into the Coös and Calciferous mica schist groups of Vermont, and the latter are by Dana referred to the Lower Helderberg, I have represented their age south of Canada as doubtful. In order to call attention to the existence of a gneissic series in Ontario newer than the Laurentian, though its place in the column is unknown, we have colored the Hastings group of Vennor the same as the Montalban.

There is a discrepancy in the maps of the country between the Lake of the Woods and Red River. Bigsby, in 1842 [*Quar. Jour. Geol. Soc.*, London], described Upper Silurian limestones *in situ* upon the west shore of the Lake of the Woods. Prof. Hind, in 1860, extends this group of fossiliferous rocks westerly and southerly into Minnesota, to the latitude of 46°. Logan's maps differ. The small one makes a broad strip of Devonian extend entirely through Minnesota to connect with the exposures of this age in Iowa. This is accompanied by a broader area of the Trenton from Red River to Lake of the Woods, and to Lat. 45°, where its width is much diminished and is continuous into Iowa. The larger map has the Devonian terminate abruptly about twenty-five miles south of the international boundary; and the Trenton has less width, reaching to Todd and Douglass counties. West of the Lake of the Woods is an area of Niagara, continuous thence along the international boundary to Rainy Lake.

G. M. Dawson, in the Boundary Survey, colors the entire area between the Lake and Red River as Paleozoic. Professor Bell divides this area midway between these points, giving half to the limestones and half to the Laurentian; and thinks the supposed fossiliferous outcrops about the Lake of the Woods consist of transported boulders. Our representation shows all of northern Minnesota as uncertain—by means of broken colors—and disposes of a part of the troublesome area by giving the limits of the former glacial extension of Lake Winnipeg—called Lake Agassiz by the Minnesota Geological Survey. From Lake Traverse to the mouth of the Saskatchewan, there is hardly a rocky outcrop—so that the use of the yellow color for the Quaternary is eminently appropriate. To the north of the Saskatchewan, where the ledges are plenty, the limits of the lake are also shown by suitable markings. Many of the

enormous Huronian areas east of Lake Superior are shown in broken colors, because their limits have not yet been worked out. Concerning the representation of the country west of the Rocky Mountains, remarks will be made further on in the mention of Washington Territory.

NEW ENGLAND.

The compiler is alone responsible for the delineation of the geology of New England—making use of all the official reports, so well known, combined with personal field-work. The map, when mounted, well shows the difficulty of calling the New England gneisses by other names than are commonly assigned to them from Alabama to the Highlands of the Hudson, *i. e.*, Laurentian with pre-Silurian accompaniments. The range is a continuous one from Alabama to Canada, consisting of gneisses, and bordered first by the Cambrian sandstones, derived from the ruins of the gneiss; thence by the great Appalachian Lower Silurian limestone valley. If orography is determined by stratigraphy, then the gneisses of New England are mainly of pre-Silurian age. A contour or relief map would illustrate this position even more strongly than colors.

The typical Montalban rocks in New Hampshire underlie the Huronian; and we understand the same to be true of all the gneisses upon the Atlantic slope colored as distinct from the Laurentian. The Laurentian areas in New England are usually ovoidal in shape, and of limited extent; and in the preneval history must have formed a congeries of islands before the interspaces became filled by the Atlantic gneisses. The more important of them are Formations K₂, K₃, of Percival, in western Connecticut; Formations A and B of Percival in eastern Connecticut, with their respective continuations into Massachusetts and Rhode Island; the Stamford granite and gneiss east of

Bennington, and the Chester gneiss range of Vermont; gneissic areas east of Worcester, and underlying the Boston Cambrian basin in Massachusetts; the porphyritic and Bethlehem protogene tracts in New Hampshire and the coastal gneisses east of Portland in Maine.

Eruptive granites are distinguished in New England, Canada, South Carolina, Georgia, and to a limited extent in the far west. This is but a tithe of what will be separated from the gneisses hereafter.

NEW YORK.

Our authorities for this State are mainly the published map of the Geological Survey, and a manuscript map prepared by Prof. R. P. Whitefield, showing the improvements obtained under the directions of Prof. James Hall in the Catskill mountain region and elsewhere, and exhibited to the public in the American Museum of Natural History at Manhattan Square. East of the Hudson, Prof. Dana's recent observations may authorize us to enlarge the Laurentian area called K1, by Percival. We accept his theory of the superior position of the Westchester county gneisses to the Laurentian; but cannot yet see the way clear to call them Silurian. Farther north we follow Mather's view of the Lower Silurian age of nearly all the rocks east of the Hudson, taking note, however, of certain limited Cambrian exposures, and anticipating a greater extension of them hereafter at the expense of the clay slates and talcoid schists once referred to the Taconic system. In the Adirondacks an area of Labrador is given, as well as possible, from Prof. Emmons' limits assigned to the hypersthene rocks. Various hints suggest the future discovery of Huronian and Montalban terranes within this elevated district. Mather's reference of the Long Island division to the Cretaceous seems to be confirmed, while the Tertiary may also occur beneath the Quaternary.

NEW JERSEY.

Prof. G. H. Cook's latest reports are followed implicitly. He does not state definitely in his printed reports which division of the Tertiary prevails in the low ground next to the ocean, for want of outcrops; but authorizes us to call it upper Tertiary as far as Chesapeake Bay. The former extent of the Hudson River valley out to sea is shown off the coast of New Jersey by the sub-marine contour lines. What the age of the formations may be in this submerged district is doubtful. Perhaps the discovery, by Cook, of Devonian fossils in certain Cretaceous beds as rolled pebbles may indicate the presence of Paleozoic strata in this lost Atlantis.

PENNSYLVANIA.

The Second Geological Survey is in progress, and its results have been utilized by us for the following counties: Erie, Crawford, Mercer, Venango, Lawrence, Beaver, Butler, Washington, Alleghany, Westmoreland, Fayette, Armstrong, Clarion, Greene, Fulton, Blair, Huntington, Adams, York, Lancaster, Lehigh, Northampton, Dauphin, Lebanon, Northumberland, Montour, Union, Snyder, Perry, Clinton, Lycoming, Sullivan, McKean, Tioga, and Potter. Elsewhere Rogers' map has been followed, and made to fit the new coloration somewhat arbitrarily. The members of the survey differ in their estimates of the age of the crystallines along the Susquehanna. Frazer's map of the gneissic areas is so unlike that of Rogers, and of Tyson in Maryland, that the forcing of a connection between them is less felicitous than usual. It seems to us as if the lower Carboniferous group has too great an extension in the northeastern part of the State, upon which the Second Survey have not yet reported. If the Catskill sandstone were

distinguished upon our map, it would display the continuation of all the Carboniferous synclinals into New York.

MARYLAND, DELAWARE, VIRGINIA, WEST VIRGINIA.

No changes have been made in the delineation of Maryland and Delaware since the publication of the Census maps. For the Virginias we have had, first, the use of Prof. W. B. Rogers' manuscript map; second, the publication of the same upon a small scale in the report of Maj. Jed. Hotchkiss; third, Prof. Rogers' notes in Macfarlane's railway guide; fourth, letters from Prof. W. M. Fontaine, of the University of Virginia; and fifth, the *Virginias* by Maj. Hotchkiss. The railway guide gives us the reference of the Fairfax gneiss areas, west of Richmond, and from Liberty to near Lynchburg, to the Laurentian; and the Mesozoic areas south of Richmond. Prof. Fontaine named for us the Laurentian west of Lynchburg and Amherst; and furnished us a tracing showing the Huronian limits from the Potomac to Willets mountain. Subsequently he writes that these limits may be extended farther, viz., "the three counties of Floyd, Carroll, and Grayson are composed of metamorphics like those found composing the Blue Ridge further north; *e. g.* at Harper's Ferry. Hence they are Huronian, if there is any Huronian in the Blue Ridge ranges. The line of junction of the metamorphics and primordial rocks is to be found almost always, if not always, just along the southeast foot of the ranges called Pilot, Poplar-Camp, and Iron mountains. The metamorphics are hydro-mica and chlorite slates, sometimes with epidote; some hornblende schist; a great deal of felsite, sometimes with copper; also a singular gneissoid rock, having shot-like particles of bluish quartz, of a waxy lustre, etc. You will note that the range of Iron mountain near Balsam

mountain heads south, while it dies down in the original southwest direction. The new range, now called Iron and Smoky, is, near White Top, certainly Huronian if we have any in the Blue Ridge."

This letter agrees with a map of this neighborhood by R. O. Currey, made in 1859, and published in the *Virginias* for April, 1880; though the term Huronian is not used by Currey. It also seems to agree with the map of Professor Kerr in the North Carolina geological report, whose two Huronian bands correspond nearly with the position of the Virginia areas as described by Currey and Fontaine. Dr. T. Sterry Hunt, on the contrary, is quite positive that these two bands in North Carolina should be referred to the primordial, the eastern band extending into Georgia to merge into the itacolumite or "principal gold region" of the geological map published in White's Statistics of Georgia. Our representation of these areas follows the latter author for North Carolina, and no effort is made to separate any of the Eozoic groups in Alabama and much of Georgia.

THE ATLANTIC PLAIN.

Adjoining the coast from New Jersey to Florida, and thence through the Gulf States, is a low, broad country, sometimes called the Atlantic plain, underlaid by Cretaceous and Tertiary beds, which are commonly concealed by the Quaternary. It is most perfect in its development in the Gulf States, where the upper Cretaceous line may be several hundred feet above the sea; to the north of Georgia the rivers wind through marshy districts after leaving the crystallines. It is not difficult to see that they are drowned lands, and entirely submerged east of New York, save the islands Long, Block, Martha's Vineyard, etc. The plain is traceable by soundings to join the Great Banks of New-

foundland, and the fishermen constantly bring in Tertiary fossils from this plateau east of Cape Cod. The formations do not skirt the land concentrically over this entire plain, as several anticlinoria and synclinoria are easily made out. The first basin is in Georgia, the second in South Carolina, the third in the southern part of North Carolina, the fourth in North Carolina, merging into that depression into which the James, York, and Potomac rivers flow, making Chesapeake Bay. Because of the lowness of this land, the formations are not well defined; and we color them, as seems best, after studying Tyson's map of Maryland, Rogers', of Virginia, Kerr's, of North Carolina, Tuomey's, of South Carolina, Lyell's (1845), of Georgia. Florida is represented as wholly Quaternary; but Conrad has described Eocene fossils from its northern portion. Hilgard has distinguished himself by the patient unravelling of the embayment of the Mississippi valley, including the demonstration of a great elevation of Lower Louisiana since the Tertiary; and we regret that we cannot present all his subdivisions; enough is given, however, to illustrate his views.

The narrow strip of Quaternary between this Atlantic plain and the crystallines shown, from North Carolina to Mississippi, and, probably, not entirely exhibited, has been suggested by Tuomey to have been derived from the melting of an ice-sheet covering the crystallines of the more southern Atlantic mountains. The beds are the same as the Orange sand of Hilgard.

THE CAROLINAS, GEORGIA, ALABAMA.

The reports of Emmons, Kerr, Tuomey, Lieber, Little, Smith, etc., have been carefully studied for the solid rocks of these States. The Taconic rocks of North Carolina, clay-slates of South Carolina, also the mica, talcose, and

itacolumite series of Lieber are all ranked as Cambrian matching the rocks thus designated by Little and Smith in Georgia and Alabama. Most of the gneiss in these States is placed with our Montalban—pre-Huronian—without attempting to separate the true Laurentian from it. The eruptive granites of South Carolina are given after Lieber, who seems to have understood correctly the mutual relations of all the crystallines. More Huronian terranes remain to be distinguished in this region.

OHIO, INDIANA, ILLINOIS, KENTUCKY, TENNESSEE.

Nothing can be better than the maps of these States by Newberry, Owen, Cox, Collett, Worthen, Shaler, and Safford. If there is anything in our map unlike what has been published in these several districts, it is because of special information furnished expressly for us by these gentlemen. Professor Collett has revised for us the boundaries between the upper and lower Coal Measures for Indiana and Illinois, and designated a small Permian area, adding his opinion that the whole upper part of the Coal Measures ought to be called Permo-Carboniferous.

Upon an outline-map of Indiana recently published by Prof. Collett, certain features are differently delineated from our coloring. He does not carry the Upper Silurian bridge across the western third of the State to connect with the same strata in Illinois. Our coloring was based upon the detailed statements of counties in R. Owen's report, and is certainly to be depended upon as far as Rensselaer. The gap between is entirely covered by drift-deposits, so that the broken color is appropriate for this missing link. The precise northern extent of the Lower Carboniferous, next Illinois, and the boundary between the Devonian and Upper Silurian in the northern part of Indiana are, as yet, only conjectural. Collett cuts off the spur of the Coal

Measures made to reach Templeton, and elongates the projection of the same into Munroe County more than we have done. Our outline was derived from a study of Professor Cox's report.

MICHIGAN.

Winchell's and Rominger's maps of the lower peninsula are quite complete. Pumpelly's and Brooks' maps are used for the upper peninsula. Brooks recognizes the Montalban of the East in the upper part of the Laurentian, which is left uncolored upon the Michigan published map. It extends into Wisconsin, but is not separated from the Laurentian upon our sheet; neither are the formations XIX, XX, XXI, recognized by Brooks, as like the New Hampshire Coös group, shown distinct from the Huronian.

WISCONSIN.

The myriad details of Chamberlin's maps cannot be reproduced upon our scale, but are generalized by us without intentional deviation. To Chamberlin and Irving we owe a late representation of a considerable Huronian area, reaching from Michigan nearly half way through Wisconsin, not yet published officially. The Keweenawan rocks are placed under Cambrian colors, since it is shown to be post-Huronian, while older than Potsdam.

IOWA, MISSOURI, ARKANSAS.

The maps of Hall and White are followed for our guidance, with an improvement of the mutual limit of the Lower and Upper Silurian sent us by W. J. McGee; and it was found necessary to shift the line dividing the upper and lower Coal Measures, in order to match the corresponding horizon in Missouri.

Professor Swallow communicated to us a manuscript map of Missouri many years since, which proves to be in entire agreement with the later publications of Broadhead and Pumpelly. As the later publications did not cover the entire territory, there are considerable areas in our compilation given to the public now for the first time.

The data for Arkansas have been compiled by Prof. Richard Owen from the reports of his brother D. D. Owen, with slight emendations along the Mississippi valley, taken from Humphrey's and Abbot's Hydrology of the Mississippi, and the enlargement of the Cretaceous in the southwest part. As is well known, the Coal Measures of Arkansas are only just above the Conglomerate or Mill-stone grit.

KANSAS, TEXAS, AND INDIAN TERRITORY.

The latest map of Kansas was published by Professor B. F. Mudge in the report of the State Agricultural Society for 1878. He had the advantage of several years' work in collecting fossils for the Peabody Museum of Yale College, in addition to two years' official employ by the State, and his conclusions are unlike those of his predecessors and neighbors, though, probably, nearly correct. He throws out the Trias altogether, believing that the red beds of Hayden and Newberry, with the accompanying gypsum, belong to the lower Cretaceous, and draws the west line of the Permian southwest to strike the northwest angle of Indian Territory. As this view is not acceptable to the other geologists named, I have shown a restricted area of Trias with a broken color, giving portions of it to both the Cretaceous and Permian. Except, so far as is required to be consistent with the above rendering, there is no variation in the representation of the rocks in Indian Territory and Texas from

the last edition of our United States map in Walker's Atlas. The reference of the Llano Estacado to Cretaceous is opposed by Marcou, who regards it as Jurassic. South of Kansas, the boundary between the upper and lower Coal Measures is entirely conjectural.

Professor Mudge refers large areas of Kansas, particularly the northwest portion, to the Pliocene. This is at variance with the color of eastern Colorado by Hayden, who represents the Laramie group as impinging against Kansas. Being unable to give the proper boundary between these groups, I have allowed each to extend to its State line, inserting at the northwest angle an indefinite area of the middle Tertiary, upon the authority of Prof. E. D. Cope.

MINNESOTA.

Prof. N. H. Winchell has patiently answered numerous questions concerning the Minnesota rocks; and he regards the present coloration as provisional. We get, however, a great improvement over the delineations of the earlier editions. The use of Lake Agassiz has been already mentioned. No systematic explorations of the northern portions of the State have been made; and the colors are broken, where the compiler would have preferred to leave a blank space, after reading the reports of Schoolcraft, Nicollet, Owen, Logan, Dawson, Bell, Hind, and Winchell. Very few ledges occur, the country being covered by drift. The areas of Silurian, Devonian and Cambrian east of Lake Agassiz may possibly have no better tenure than the presence of erratic blocks derived from the northwest. Professor Bell has described minutely several bands of the Laurentian and Huronian along the international boundary from the Lake of the Woods to Lake Superior, and these are made to extend far into

Minnesota. The Vermilion Lake terrane is traced across to Alexandria. The Laurentian is confined to the northern part of the State; or, at least, the reference of the granite and gneiss along Minnesota river to this series is doubtful. The Laurentian and Huronian rocks occur in oval patches in Minnesota, as in Michigan and Wisconsin, rather than in one broad stripe, yet making an Eozoic promontory reaching nearly through the State, the counterpart of the Adirondack peninsula in New York. Abrupt connections in the coloring between Minnesota and Canada represent differences of opinion as entertained by the respective government geologists. One of the Minnesota areas of Huronian reaches to Taylor's Falls on the St. Croix, and is suggested by Winchell as the continuation of the same rock a few miles distant in Wisconsin. Only a thin covering of Potsdam conceals it between the known outcrops. The quartzites, etc., of the pipestone region are regarded as Potsdam. Quite an extensive area of quartzite gneiss and granite is covered by the Cretaceous in the southwest part of the State. If it were possible to use both the pink and green colors for the same area we should do so here, as the country is essentially a Cretaceous plain showing the crystallines where it has been deeply cut by rivers. Winchell restricts the Potsdam to narrower limits than those represented (after Bell) where it passes into the Dominion adjoining Lake Superior.

NEBRASKA, DAKOTA, WYOMING, MONTANA.

The foundation to our knowledge of these districts, was given us by Hayden in the map accompanying the Reynolds expedition, and the final report upon Nebraska. The changes consist in calling the Lignite Tertiary Laramie, giving some data from the notes of E. S. Dana and G. B. Grinnell, for the Yellowstone Army Expedition, and from the

Black Hills map of Newton, prepared under the direction of J. W. Powell. Prof. Hayden's maps and reports have afforded us the principal data for the delineation of the immense areas of Wyoming and Montana. Permission was given us to copy from several of his maps in advance of their publication.

In Hayden's map, illustrating the Reynolds expedition, the whole of Montana is colored with much precision. That which lies east of the crystallines has been modified considerably by Hayden's later expeditions. He gives notes of the rocks at Jefferson, Helena, and at the Forks, also panoramic views, but very scanty maps. We therefore follow the Reynolds map, save where it has been differently described in later publications. The maps, in the reports of 1877, 1878, for the Yellowstone Park and farther south, are of great value for the northwest part of Wyoming. In the earlier map, all the volcanic and crystalline rocks were not distinguished from each other; and hence the use of a similar color for the entirely unexplored region of the west part of Montana and the east part of Idaho must be regarded merely as a cover for ignorance. The principal part of Wyoming is likewise taken from the Reynolds map.

GOVERNMENT SURVEYS OF TERRITORIES.

The elaborate geological maps of the Fortieth Parallel Survey under Clarence King; of Colorado and much of Wyoming under Prof. F. V. Hayden; of the Geographical and Geological Surveys under Lieut. Wheeler, especially in New Mexico, Arizona, Utah, and Nevada; of the various reports prepared under the direction of Major J. W. Powell, as Dutton's High Plateaus of Utah, the Colorado River and Uintah Mountains, the Henry Mountains by G. K. Gilbert, the unpublished map of the Black Hills by H.

Newton, etc., have all been consulted, and so far as practicable transferred to our sheets.

For New Mexico the data have not been so complete. Our sources of information are J. Marcou's Pacific Railroad and other reports, 1857; Prof. J. S. Newberry's report in connection with the Macomb Expedition; annual reports by Prof. E. D. Cope and H. Loew to Lieut. Wheeler, 1874; the extension of the coloring of Hayden's Colorado atlas for about fifteen miles into the territory; and Prof. J. J. Stevenson's observations made for Lieut. Wheeler, in a tract south of the north line of New Mexico to lat. $35^{\circ} 15'$, and between long. $104^{\circ} 15'$ and 106° . Cope and Stevenson agree that the Carboniferous strata east of Santa Fé should be referred to the Coal Measures rather than the Lower or Sub-Carboniferous; and it is likely that much of what we have referred to the Lower Carboniferous in the southeastern part of the territory and in Texas is of the same age. Prof. Stevenson finds gypsum beds, similar to those in the Indian Territory and referred to the Trias, apparently situated in the Dakota group of the Cretaceous; and thus suggests a problem for future study, analogous to that propounded by Mudge in Kansas. He also has defined for us the eastern limit of the Laramie group, bringing it to the Raton Mountains to the southeast of Trinidad, Col. The delineation of the northwest part of Arizona and of southern Utah was taken from the maps of the Wheeler Survey. Since then Messrs. Powell, Howell, Gilbert and Dutton have fashioned elegant relief maps of the same regions, presenting differences in detail from the original Wheeler sheets. I have followed the later authorities in the coloration of the volcanic masses in N. W. Arizona, and in minor changes about the Aquarius plateau in Utah. The Permian in Arizona is given approximately from information furnished by C. D. Walcott.

The Huronian is given for the Black Hills, but not for any other part of the territories, although supposed by King to exist extensively in them, especially in the more eastern portions. North of the Fortieth Parallel Survey, in Wyoming and Nevada, are extensive blank areas, for which we can find no data of representation. It would have been better perhaps to leave a greater part of southern Nevada in the same condition. In Western Nevada, California, Oregon, Montana, and Idaho, the tint for Lower Carboniferous is intended to signify Paleozoic strata in general, though the Carboniferous is well defined in Northern California. Likewise the older Tertiary tint in the same State signifies Tertiary strata of any age.

CALIFORNIA.

The California portion of the map is colored from material furnished chiefly by Prof. Wm. P. Blake, using as a basis his geological map of May, 1857, in the fifth volume of the Pacific Railroad Reports, our census maps, and the results of recent explorations.

The crest of the Sierra Nevada consists mainly of granite and crystalline schists of pre-Silurian age, and believed to be in part, at least, Huronian. For a part of the length of the range these rocks are flanked on the west by Paleozoic limestones, quartzites, and slates traversed by auriferous veins. Lower down the slope, serpentine rocks are frequent, and there is a broad belt of slates, also auriferous, referable to the Mesozoic period and believed to include the Triassic and Jurassic formations. These formations disappear at the southern end of the range, while at the north they occupy a greater breadth, but are largely covered by volcanic overflows. Upon the eastern side of the range, especially from Mono Lake southwards, there is a well-marked line of volcanic vents in the form of extinct

conical craters surrounded by lava streams. There are also some extensive lava flows on the opposite and western slope, such as Table Mountain in Tuolumne County, and upon the Upper San Joaquin. The chief area of former volcanic outflow is, however, at the north, toward the Oregon line, joining the vast volcanic area of the Cascade range. In this part of the State, Lassens Peaks, Shasta Mountain, and the Marysville Buttes are prominent volcanic centres.

The Cretaceous and Tertiary formations are largely developed in the Coast Mountains, both north and south of San Francisco, with, also, limited areas of granitic rocks, notably at Monterey, the Farallone Islands, and upon Tomales Bay. There is also a broad belt of granite in the foot-hills crossing the American River and extending through Nevada County.

The Post Pliocene and recent formation cover a considerable area of the State, especially in the central valley of the Sacramento, the San Joaquin, and the Tulares, and farther south at the head of the Gulf of California, where the dry bed of an ancient lake is now below the sea level.

Extensive areas of the State, especially at the north and west, have not yet been explored geologically, and the coloring upon such portions is hypothetical. Prof. Newberry has given us the use of his notes upon the north-eastern section along Pitt River, etc.

BRITISH COLUMBIA AND VANCOUVER'S ISLAND.

G. M. Dawson sent us a manuscript map of British Columbia, based upon his own and Mr. Selwyn's observations, which has since been published in the Canada report. The Tertiary, Cretaceous, and older intrusive rocks are well defined. The most western Tertiary area is Miocene, and is connected with the Washington terrane:

determined to be of this age by Prof. Newberry and George Gibbs from the plants found at Bellingham Bay. Dawson suggests that Laramie beds may also occur in the neighborhood, perhaps equivalent to the Cretaceous coals of Vancouver. The little part of Vancouver's Island represented is copied from the Canada maps by Selwyn and Richardson. Most of the island is composed of crystalline rocks, partly volcanic, and shown by Selwyn to be not older than Carboniferous. We apply to them upon the map the indigo tint given to the Carboniferous generally in the Rocky Mountain region. Another set of crystalline rocks occurs between longitudes 121° and 122° . They are repeated east of the Okinakane River; and I have ventured to extend the same coloration as far east as the Kootenay River, so as to correspond with the observations by George Gibbs in Washington. They seem to be the metamorphic rocks of the Coast and Gold ranges. Between the two areas mentioned, lies the Cache Creek group of Selwyn, much like the Vancouver Island series and including some Triassic strata. This distinction into Cascade and Cache Creek groups was not recognized by Gibbs south of the international boundary line. East of the Kootenay, the rocks are certainly Paleozoic, largely of Carboniferous age, as determined by Dawson, and the indigo tint is used to represent them. The Crystalline rocks mentioned were called granite and Huronian by Dr. James Hector, geologist of Capt. J. Palliser's expedition in 1857-60. He calls the Rocky Mountain limestones east of the Kootenay Devonian.

WASHINGTON TERRITORY.

The remotest corner of our map is one of the most difficult to color satisfactorily, and is based upon the information furnished for Columbia by Selwyn and Dawson,

George Gibbs, and Thomas Condon, State Geologist of Oregon. It is supposed that the Olympic mountains consist of the Vancouver Island crystalline rocks, which, in their extension southwards, are much covered by volcanic overflows. It is thought best to use the pink Laurentian tint for those crystallines, in the absence of information of the precise locality where the ancient gneisses commence to occur. Condon furnished the statements for Macfarlane's railway guide for this territory, whence it appears probable that Cretaceous rocks follow the western border of the Cascade range, but certainly at Skookum Chuck, Vashon Island, and Seattle. It is probable that this Cretaceous is bordered by the Eocene, and it is represented at Steilacoom. Gibbs describes the Miocene in Puget Sound, and finds it replaced by granitic rocks, about twenty miles up Skagit River, which extend thence entirely across the territory near the northern boundary. We use the pink color to represent them, though it seems probable they are the equivalent of the later Cascade and Cache groups described in Columbia. It is impossible for us to draw the line between the older and newer crystallines here.

Similar difficulties present themselves in attempting to color the formations in the eastern part of Washington, Idaho, and parts of Montana. Excepting the small southward extension of the Paleozoic tint east of Kootenay, I have followed Hayden's map in the report of the Reynolds expedition, but using a broken tint so as to express the uncertainty existing as to the reference of the whole area to the crystalline and igneous series. Certain mining men assure me that the Cœur d'Alene mountains are granitic; and others represent that the Salmon River region of Idaho is only partially underlaid by the crystallines.

The reference of an enormous territory in Washington

to volcanic overflows is well established. According to Condon and Le Conte those sheets overlie Miocene deposits in the gorge of the Columbia through the Cascade range. Mts. Rainier, Baker, St. Helens, Adams, Hood, and Jefferson, are some of the craters connected with the igneous overflow.

OREGON.

For this region we had a manuscript map colored for us by Professor Condon ; and it was our lot to collect some additional information, personally, in a trip up the Columbia River and across the Blue Mts. I understand that the distinction between the volcanic and crystalline is not maintained in the coast ranges, and that some of the Cretaceous rocks in the southwest corner may be crystalline. The statements of local surveyors lead us to mark the rocks of the Snake-River Cañon as crystalline, rather than volcanic. Southern Idaho is given from my own imperfect notes.

TERMINAL MORAINES OF THE EASTERN AMERICAN ICE SHEET.

Recent speculations about the existence of terminal moraines, reaching from Cape Cod to the Rocky Mountains, are so interesting to us personally that we attempt their delineation, following Chamberlin and Upham in the main. Upham has furnished us the facts for Cape Cod, Long Island, Iowa, and Minnesota, with suggestions for Dakota. Chamberlin has outlined the course through Wisconsin, Illinois, Indiana, Michigan, etc. Mr. H. C. Lewis has given us the line through Pennsylvania, based upon observations made in 1880, and intended only for an approximation. The New Jersey line is given, as published in Professor Cook's reports. The terminal moraine seems

to occur near the southern margin of the ice-sheet from Cape Cod through to Ohio. From thence it is not known whether the moraine is similarly located; and I have, therefore, drawn the line indicating the extreme limit of the ice marking, as furnished for Ohio by Prof. Newberry, Illinois by Prof. Worthen, Missouri by Prof. Swallow, Kansas by Professor Mudge. The moraines farther north are called by Professor Cook "Moraines of Recession."

Remembering that flood-plains of sand and gravel are intimately connected with terminal moraines, Tuomey's conjecture that the belt of Quaternary skirting the solid ledges from Mississippi through Alabama, Georgia, and the Carolinas, is not unreasonable. From the writings of W. B. Rogers and W. M. Fontaine, it seems that some traces of the same Quaternary gravel may extend to Washington and Maryland, though those gentlemen differ in their views of its age.